INDOOR AIR QUALITY ASSESSMENT

L.D. Batchelder Elementary School
2 Peabody Street
North Reading, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

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Background/Introduction

At the request of Wayne Hardacker, North Reading School Department Supervisor of Buildings and Grounds, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality and health concerns at the Batchelder Elementary School, North Reading, Massachusetts.

On November 20, 2000 Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) Program conducted an indoor air quality assessment. Mr. Holmes was accompanied by Mr. Hardacker for portions of the assessment. Reports of headaches, temperature complaints and exacerbation of allergies that occupants believe to be attributed to the building prompted this assessment.

The school is a two-story brick structure with three wings (see Figure 1). The original school building was constructed in 1917. Two wings, flanking the original structure, were added in the 1920's. A two-story addition was constructed in the 1940's and lastly, four modular classrooms were added in 1997 to the rear of the building. Windows are openable throughout the building, however a number of occupants have complained that they are difficult to operate.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses grades K-5 with a student population of approximately 480 and a staff of approximately 40. The tests were taken under normal operating conditions. Test results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in all areas surveyed, indicating an overall ventilation problem in the school. It is also important to note that a number of classrooms with elevated carbon dioxide levels were sparsely populated or unoccupied, which indicates little or no air movement. Further, windows were open in a number of areas during the assessment, which can reduce carbon dioxide levels.

As discussed previously the school is comprised of four sections, each outfitted with a different type of ventilation system, some of which are operating. Due to the complexity of the building's ventilation systems this section is subdivided into four sub-sections.

Original 1917 Building

The 1917 wing does not have an operating mechanical system. The original ventilation system appears to have been intentionally abandoned. Originally, ventilation was provided by a series of louvered vents. Each classroom has an approximately 3' x 3' grated air vent in the center of an interior wall near the ceiling (see Picture 1) which is connected by a ventilation shaft to a vault-like room in the basement (see Picture 2). A corresponding 3’ x 3’ vent exists in each room (see Picture 3) near the classroom doorway that is connected to an exhaust ventilation shaft that runs from the roof to the basement. Classrooms were constructed around these shafts to provide exhaust ventilation.

Air movement is provided by the stack effect. Heating elements located in the base of the ventilation shaft warm the air, which rises up the hot air ventilation shafts. As the heated air rises, negative pressure is created, which draws cold air from the basement area into the heating elements. This system was designed to draw air from two sources in the basement: fresh air from a hinged window-pulley system on the exterior wall of the building (see Picture 2) and return air from the exhaust ventilation shafts. These sources of air mix in the vault prior to being drawn into the heating elements. The percentage of fresh air to return air is controlled by the hinged window-pulley system. The chains of the pulley system were designed to be set to lock the hinged window at a desired angle to limit fresh air intake. The remains of the chain and pulley system were noted in the ventilation vault. Non-openable windows have replaced the hinged window-pulley system; therefore no fresh, cool air can be introduced into the system.

The negative pressure created by the fresh air supply system also provides classroom exhaust ventilation. Each classroom is connected by ventilation shafts to the basement beneath the heating elements in a hearth-like structure. As the heating elements draw air into the hot air ducts, return air is drawn from the “hearths” at the bottom of the exhaust ventilation shafts. Negative pressure is created in these shafts, which in turn draw air into the exhaust vents of each classroom. The draw of air into these cool air vents is controlled by a draw chain pulley system. As mentioned previously, some of these vents were sealed in classrooms, therefore no means of exhaust ventilation exists.

In addition, many of the control mechanisms for the natural ventilation system are not operable or are missing (i.e., pull chains and louvers) and the window systems that provided fresh air in the basement are not openable. Unless the ventilation system is restored to its original design by restoring control systems, openable basement windows and unsealing of exhaust vents, the sole source of ventilation in this building is openable windows.

Exhaust ventilation was originally provided by a natural/gravity system. Each classroom is constructed around a ventilation airshaft that terminates on the roof in a series of chimney-like structures, which have been abandoned (see Pictures 4). Above each vent of a classroom is a radiator-like heating element. The heating element would heat air, which would rise and exit the building through the rooftop vents. As the heated air rises classroom air is drawn into the vent. A number of these vents were sealed throughout the building. Without a functional exhaust system, normally occurring environmental pollutants can build up. Care should also be taken to ensure ventilation shafts are rendered airtight in classrooms and at the roof to prevent the egress of dirt, dust and drafts into occupied areas.

Supplementing the natural gravity feed ventilation system in original building classrooms is provided by openable windows. During summer months, ventilation in the school is controlled by the use of openable windows in classrooms. This section was configured in a manner to use cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. In addition, the building has hinged windows located above the hallway doors. This hinged window (called a transom) (see Picture 5) enables classroom occupants to close the hallway door while maintaining a pathway for airflow. The design allows for airflow to enter an open window, pass through a classroom and subsequently pass through the open transom. Airflow then enters the hallway, passing through the opposing open classroom transom, into the opposing classroom and finally exits the building on the leeward side (opposite the windward side) (see Figure 2). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or transoms are closed (see Figure 3). Transoms are opened using a rod/hinge system. Most transoms in these wings are inoperable. The doorframes appear to have been painted, resulting in the repeated coating of the transom control rods.

1920's Wings

Fresh air in classrooms is supplied by a unit ventilator (univent) system located in a loft between classrooms, which serve as air-mixing rooms (see Pictures 6 & 7). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (see Picture 8) and return air through an air intake located at the base of each unit (see Figure 4). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the front of the unit.

Although univents were radiating heat, none of the fans were operating at the time of the assessment. No fresh air was being mechanically provided to classrooms in these wings, since all outside air intakes were sealed with plywood (see Picture 9), reportedly to keep rodents and pests out. Also noted were a number of materials (e.g., cardboard boxes, plastic totes) stored in these lofts which obstruct airflow to the univents as well as creating a potential fire hazard due to their close proximity to uninsulated steam pipes (see Pictures 9 & 10). BEHA staff recommended to school personnel that these materials be removed.

Exhaust ventilation for this wing consists of gravity feed exhaust vents located at floor level that are connected by ductwork to sheltered vents on the roof. The draw of air into these cool air vents is controlled by a draw chain pulley system (see Picture 11). Cold drafts were noted from some of the vents (called backdrafting), indicating that the exhaust vents do not operate. Without exhaust ventilation, environmental pollutants can build up in the indoor environment.

1940's Addition

Fresh air for classrooms of the 1940's addition is also supplied by a univent system. Univents were found deactivated in many areas. Univents in this wing do not run continuously but are activated by thermostats once room temperatures drop below a set level. When the room temperature exceeds the thermostat setting, univents deactivate. Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis. Obstructions to airflow, such as paper and boxes stored on univent air diffusers and desks in front of univent return vents, were also noted in classrooms (see Picture 12). In order for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must remain activated while classrooms are occupied.

Exhaust ventilation is provided by a mechanical system, which draws air into an ungrated hole, located at floor level in classrooms (see Picture 13). Airflow is controlled by a flue located inside the duct. This system appeared to be off in all classrooms surveyed. Throughout the school these ungrated holes were being used to store recycling bins, crates, books, boxes and files. As with the univents, in order for exhaust ventilation to function as designed, exhaust fans must be activated and remain free of obstructions.

1997 Modular Classrooms

The modular classroom wing contains four classrooms. Ventilation for modular classrooms is provided by two ducted air handling units (AHUs) located on the exterior wall of the wing (see Picture 14). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers. The amount of fresh air drawn into the units is controlled by moveable louvers connected to an activator motor that adjusts to alter fresh air intake to maintain temperature. Return vents draw air back to the units through wall or ceiling-mounted grilles. Thermostats control each heating, ventilating and air conditioning (HVAC) system (see Picture 15). In modular classrooms, thermostats have settings of "on" and "automatic". Thermostats were set to the "automatic" setting in all of the modular rooms surveyed during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 64^{o} F to 77^{o} F, which were below the BEHA recommended comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. Temperature complaints were expressed in a number of areas, which can indicate problems with the ventilation system and/or thermostatic control. Temperature control is difficult in a building with abandoned, nonfunctioning, or improperly functioning ventilation systems. In addition, many of the windows in the building are difficult to operate, which can add further to the discomfort of building occupants. Heat complaints were reported in the computer room, which contained approximately 20 computers and a number of printers. Computer equipment and printers can generate excess heat while they operate, particularly if used frequently. No mechanical ventilation could be identified in this area. Without exhaust ventilation, waste heat can build up resulting in increased discomfort. Another area of specific heat complaints was in the councilor's office. This area contains no mechanical ventilation; only a steam radiator which appeared to be oversized for the small room. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 29 to 58 percent. Most areas sampled were slightly below or within the BEHA recommended comfort range (see Tables). The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Of note were the modular classrooms, which had relative humidity measurements 9-24 percent higher than the relative humidity measured outdoors (34%) on the day of the assessment. This increase of relative humidity can be attributed to lack of airflow. Without airflow created by the mechanical ventilation system, water vapor from classroom occupants can build up, as demonstrated by these relative humidity measurements. Please note that modular classrooms also had carbon dioxide levels in excess of 2,000 ppm, which also indicates poor air exchange.

Relative humidity in this building would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A reoccurring steam leak was reported in the girl's restroom in the original building. A steam pipe travels across the rear of this area enclosed in a wood/plaster structure, which also serves as a bench. As a result of reoccurring water damage from the steam leak, the plywood has warped and become colonized with mold growth (see Picture 16).

Located in the attic was a metal drip pan installed beneath the cupola to catch rainwater. This drain pan is connected to a PVC drainpipe (see Picture 17). School maintenance personnel should ensure that this drainage system installed is properly unclogged and functioning as designed. Several areas had water stained ceiling tiles (see Tables/Picture 18). Water-damaged ceiling tiles can provide a source of mold and mildew and should be replaced after a water leak is discovered and repaired.

Water damaged wall plaster was observed in the resource room located in the basement of the original building, which indicates a current or historic water penetration problem. This room formerly served as a locker room/shower area, which was renovated into a resource room. Efflorescence (i.e., mineral deposits) was observed on the interior walls of the room (see Picture 19). Efflorescence is a characteristic sign of water intrusion. As moisture penetrates and works its way through mortar around brick it leaves behind these characteristic mineral deposits. This condition indicates that water from the exterior is penetrating into the building. The area is also carpeted. Water damaged materials such as wall plaster and carpeting can serve as a medium to support mold growth. A broken window was noted in the gymnasium and the window and windowsill in the speech room was wet with moisture (see Picture 20). Broken windows can provide a source of water penetration into the building, which can subsequently lead to damaged building materials and mold growth. The speech room is carpeted and not equipped with mechanical exhaust ventilation, which could help remove heat and moisture. When warm, moist air passes over a surface that is colder than the air; water condensation can collect on the cold surface. Over time, water droplets can form, which can then drip from a suspended surface. The cool temperature of the windowpanes would make them prone to generating condensation. Dripping condensation can lead to mold growth on porous materials (e.g., items stored on windowsills, carpeting). As mentioned previously, water-damaged carpeting cannot be adequately cleaned to remove mold growth.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Along the perimeter of the building, some of the univent fresh air intakes are located at ground level, which makes them prone to be covered with snow (see Picture 21). Care should be taken to ensure that fresh air intakes remain clear of obstructions (e.g., snow, shrubbery) to avoid the entrainment of dirt, moisture and or pollen. Also, roof drain strainers were noted clogged with debris (see Picture 22). This can result in pooling water, which can cause drain spouts to back up and overflow. These conditions undermine the integrity of the roof system and may be an indirect source of water penetration into classrooms.

Other Concerns

Several other conditions were noted during the assessment that can affect indoor air quality. Abandoned exhaust ducts stuffed with a fiberglass material were noted in the coat closets of some classrooms. If these vents are not properly sealed on the roof, backdrafting can occur which can aerosolize fibers. The coat closet to classroom 5 was open to the attic, which contains loose fiberglass insulation (see Picture 23). Fiberglass insulation can be a source of skin, eye and respiratory irritation to sensitive individuals.

The paraprofessional's office contained two lamination machines, a rizzograph photocopier, a mimeograph machine and several containers of duplicating fluid (see Picture 24). Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Lamination machines can produce irritating odors during use. Mimeograph duplicating fluid contains methanol (methyl alcohol), which is a VOC that readily evaporates at room temperature. The off gassing of this material can be irritating to the eyes, nose and throat. Methanol is also a highly flammable material, which can be ignited by either flame or electrical source. This area is not equipped with mechanical ventilation to dilute and remove excess heat and odors generated by office equipment.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners contain VOCs, such as isopropyl alcohol and butyl-cellusolve. Cleaning products were found on counter-tops and beneath sinks in a number of classrooms (see Picture 25). Cleaning products and dry erase board markers and cleaners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Also of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean in and around these areas. Dust can be irritating to eyes, nose and respiratory tract. For this reason, items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Feather dusters were observed in several classrooms. Feather dusters should be stored in a closet or storeroom. In addition, feather dusters do not remove but tend to reaerosolize household dust particles.

Inactive wasp's nests and bird's nests were noted in classrooms, which serve as learning tools (see Pictures 26 & 27). Insect parts can become dried out and aerosolized and may serve as a source of allergenic material for certain sensitive individuals. Bird's nests can contain bacteria and may also be a source of allergenic material. These items should be located away from univents to prevent the aerosolization of insect parts and/or allergenic material.

Conclusions/Recommendations

The solution to the indoor air quality problem at the Batchelder Elementary School is somewhat complex. The combination of the general conditions, configuration /modification of the building and the condition (or lack) of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality in the building. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of more immediate **(short-term)** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns. In view of the findings at the time of this visit, the following recommendations are made:

The following **short-term** measures should be considered for immediate implementation:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
2. Consider setting thermostat controls in modular classrooms to the "on" position to provide constant supply and exhaust ventilation during periods of occupancy.
3. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy independent of classroom thermostat control.
4. Remove all blockages from univents to ensure adequate airflow. Clean out interiors of univents regularly. Remove stored items from univent "loft" areas between classrooms.
5. Examine mechanical exhaust vents in the 1940's addition for function and activate if operable.
6. Regulate airflow in these classrooms with the use openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding. Contact the window manufacturer concerning proper operation/maintenance of window systems.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high

efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Ensure steam leak in girl's restroom is repaired. Replace all water damaged porous materials and disinfect areas with an appropriate antimicrobial as needed.

9. Repair any existing water leaks and replace any remaining water-stained ceiling tiles, wooden flooring and wood trim. Examine the areas above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.

10. Consider having exterior brick repointed and waterproofed to prevent further water intrusion. Repair/replace water damaged plaster. Examine surrounding non-porous areas for mold growth and disinfect with an appropriate antimicrobial if necessary.

11. Examine the cupola drain pan for proper drainage; investigate means to eliminate water penetration into cupola if possible.

12. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.

13. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

14. Inspect rooftop drains regularly to ensure proper drainage.

15. Ensure that snowdrifts are cleared from univent fresh air intakes during periods of heavy snowfall.

16. Consider relocating photocopiers to a well-ventilated area or examine the feasibility of installing local exhaust ventilation.
17. Consider reducing or discontinuing use of mimeograph machines.
18. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
19. Seal all areas of egress from the attic into classroom coat closets (e.g., spaces, abandoned vents) to avoid the aerosolization of dirt, dust and particulates into occupied areas.
20. Encapsulate exposed pipe insulation to avoid the aerosolization of fiberglass fibers.
21. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
22. Store chemicals and cleaning products properly and out of the reach of students.
23. Consider removing wasp and bird's nest from classrooms and bringing in on an as needed basis.

The following **long-term** measures should be considered:

1. Based on the age, physical deterioration and availability of parts, the BEHA strongly recommends that an HVAC engineering firm evaluate the school's ventilation systems.
2. Once univents are functioning properly, remove obstructions from the univent air intakes, ensure fresh air intake louvers are operable, repair/replace as needed. Install wire mesh or other like material to prevent occupation by birds/pests.
3. Examine the feasibility of restoring the original gravity feed ventilation system. This may entail repair or replacement of heating elements located in ventilation shafts; repair of broken or missing warm air and cool air pulley chain/louver door systems to provide ventilation in this building as designed; repair of the hinged-pulley system and/or installation of openable windows in basement area to provide fresh air to classrooms. If restoration is not an option, consideration should be given to installing a mechanical ventilation system in the original building.
4. Restore transoms to enhance airflow during warm weather. Be sure to close transoms at the end of the school day. To aid in the draw of fresh outdoor air in warm weather, use portable fans directing air out windows on the leeward side of the building. Fans positioned in this manner will serve to increase the draw of outdoor air across a floor without interfering with the natural internal airflow pattern of the building. To aid cross ventilation, open hallway doors in areas with inoperable transoms.

5. Consider installing a local exhaust vent to help remove moisture and condensation in the speech room. Locate exhaust ventilation in cafeteria.
6. Consider reducing the heat load in the councilor's office by installing a smaller radiator more proportionate to the room size and occupancy.
7. Examine the feasibility of installing a heating, ventilating and air conditioning system in the computer room to circulate air and reduce heat load generated by computers and related equipment.

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Figure 2 **Cross Ventilation in a Building Using Open Windows and Transoms**

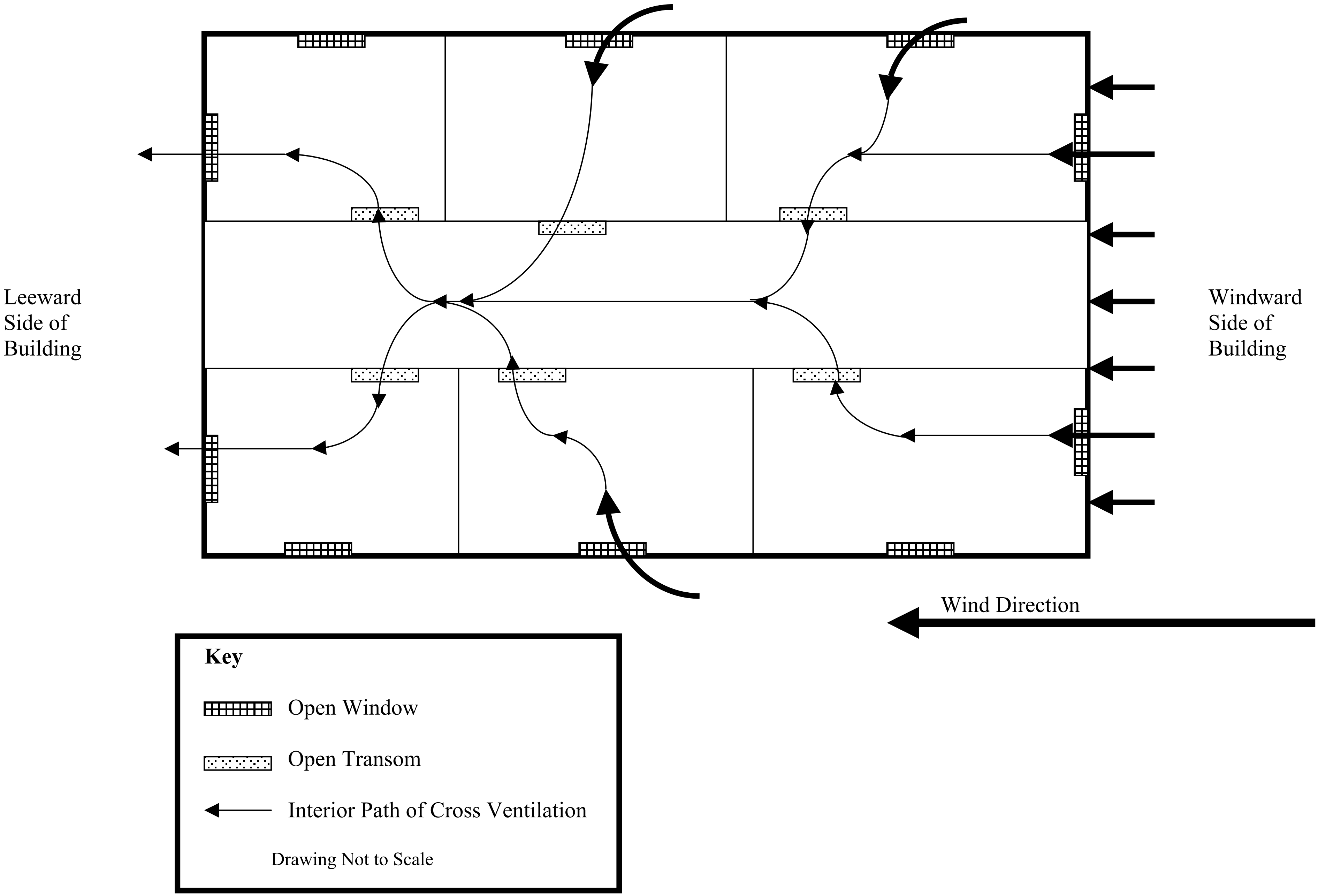


Figure 3 **Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed**

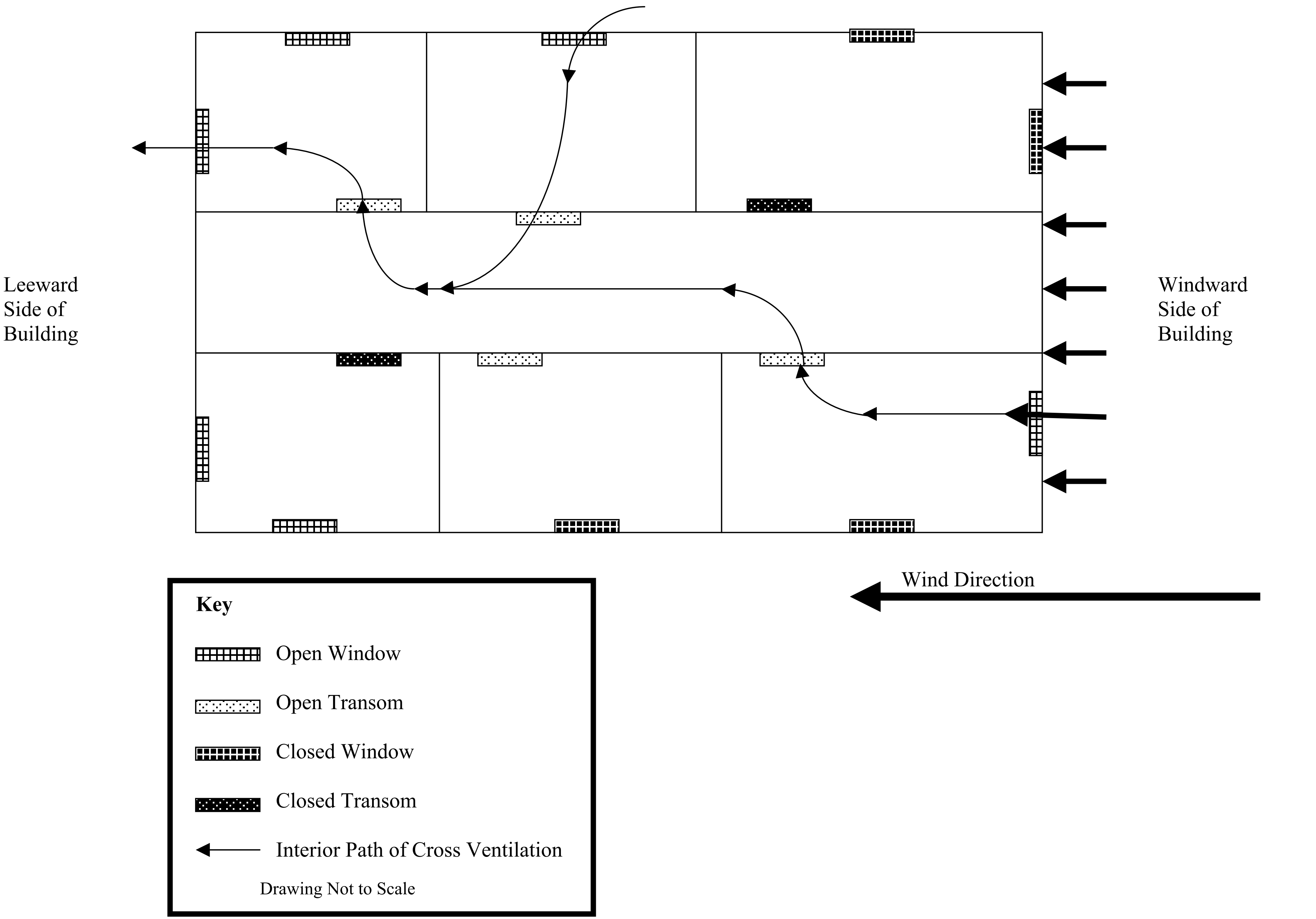
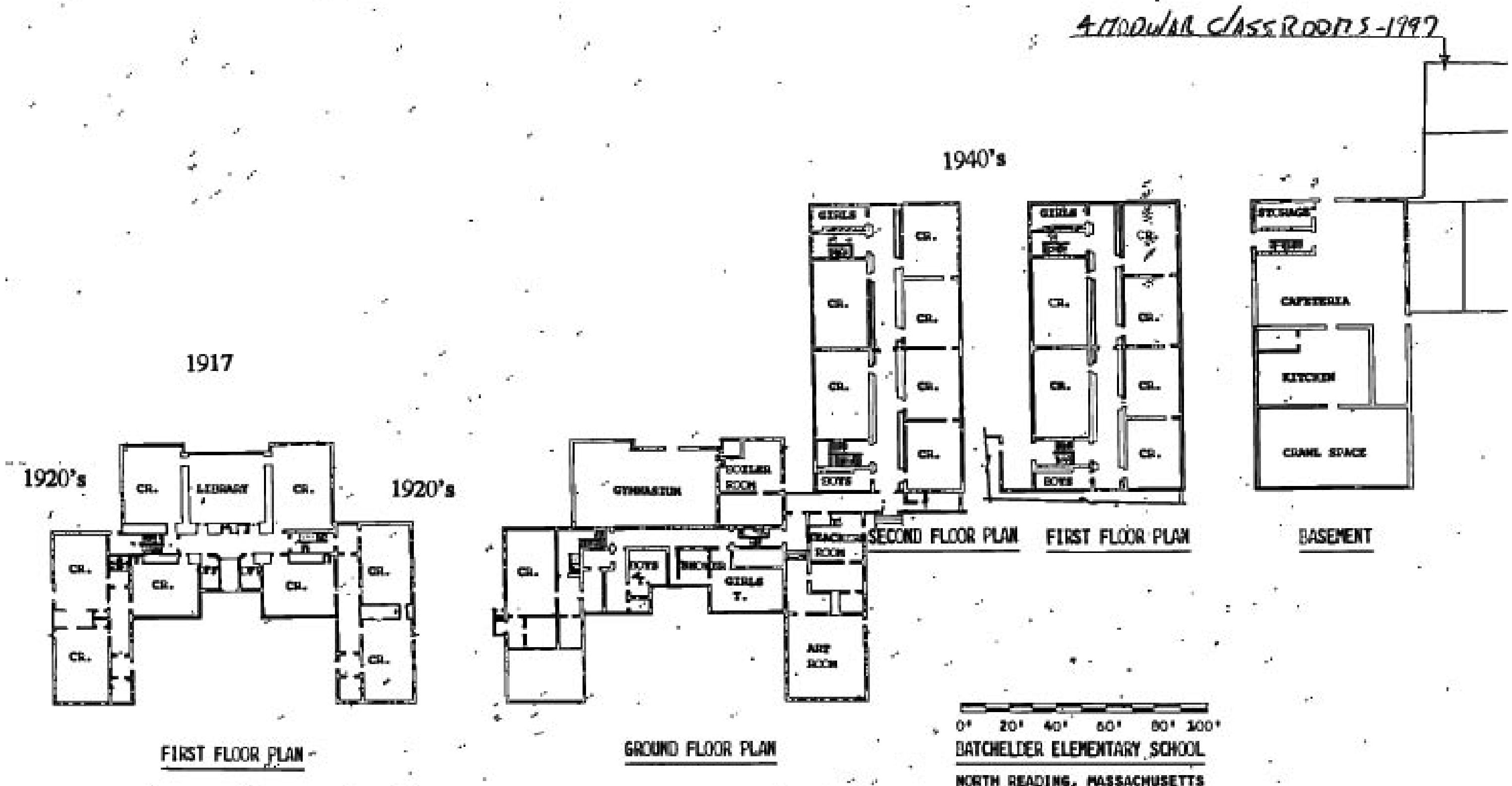


FIGURE I


4 MODULAR CLASSROOMS-1997
1917
1920's
1920's
1940's
CR.
LIBRARY
GYMNASIUM
BOILER ROOM
BOYS
GIRLS T.
ART ROOM
GIRLS
STORAGE
CAFETERIA
KITCHEN
CRAWL SPACE
FIRST FLOOR PLAN
GROUND FLOOR PLAN
SECOND FLOOR PLAN
FIRST FLOOR PLAN
BASEMENT
0' 20' 40' 60' 80' 100'
BATCHELDER ELEMENTARY SCHOOL
NORTH READING, MASSACHUSETTS

Picture 1

Natural/Gravity Supply Vent

Picture 2

Former Air-Mixing Vault in Basement

Picture 3

Natural/Gravity Exhaust Vent

Picture 4

Sealed Chimney on Roof

Picture 5

Transoms Located above Classroom Doors

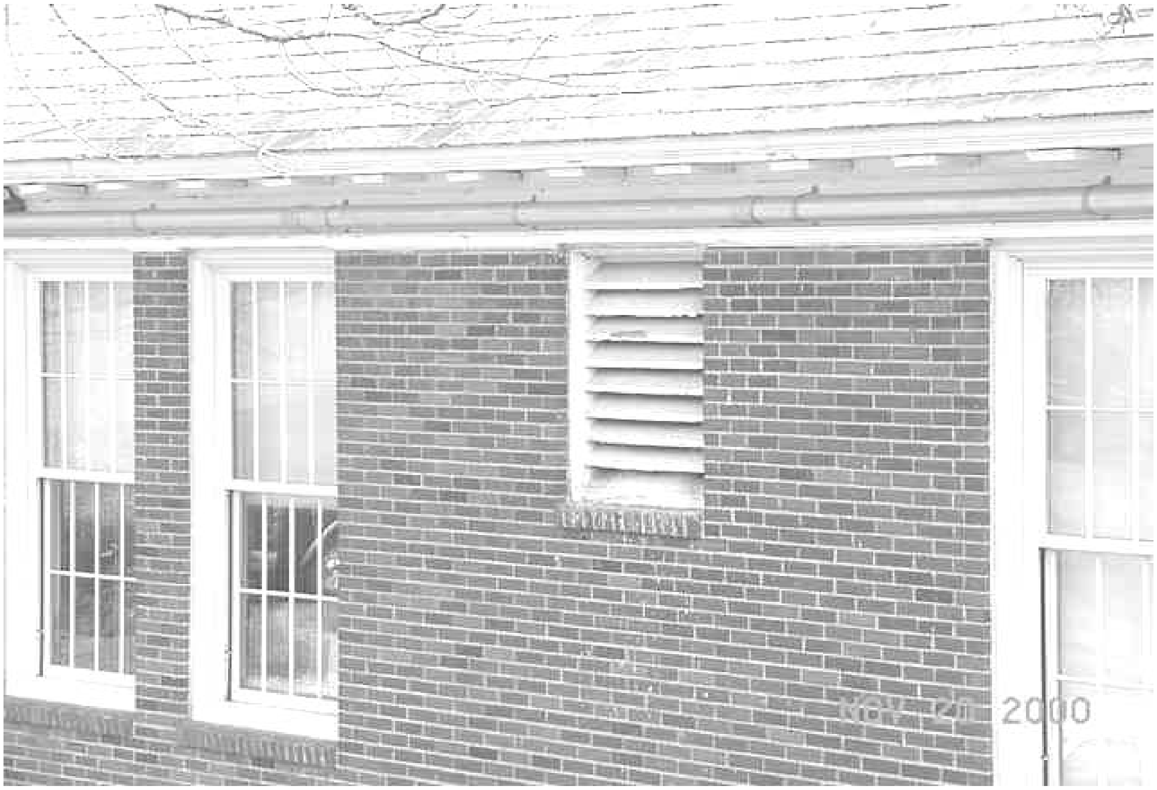
Picture 6

Classroom Univent 1920's Wing

Picture 7

Access to Univent "Loft" (Air-Mixing Room) between Classrooms

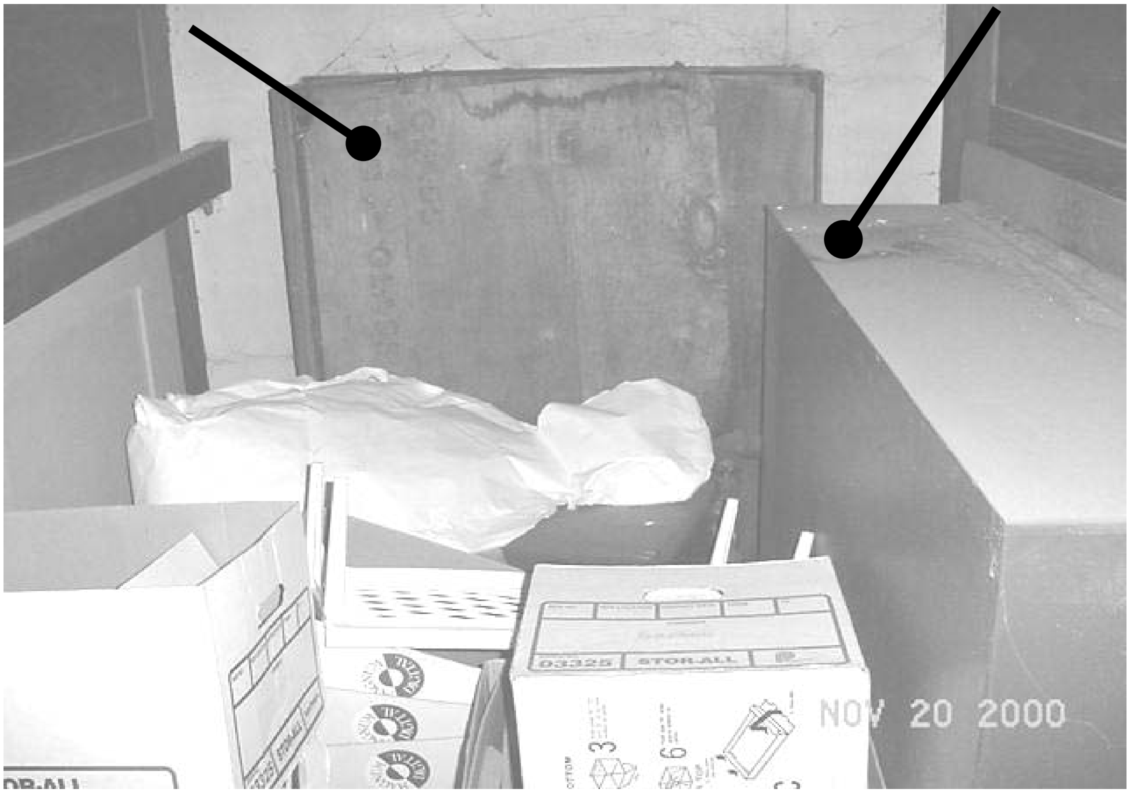
Picture 8



Univent Fresh Air Intake 1920's Wing

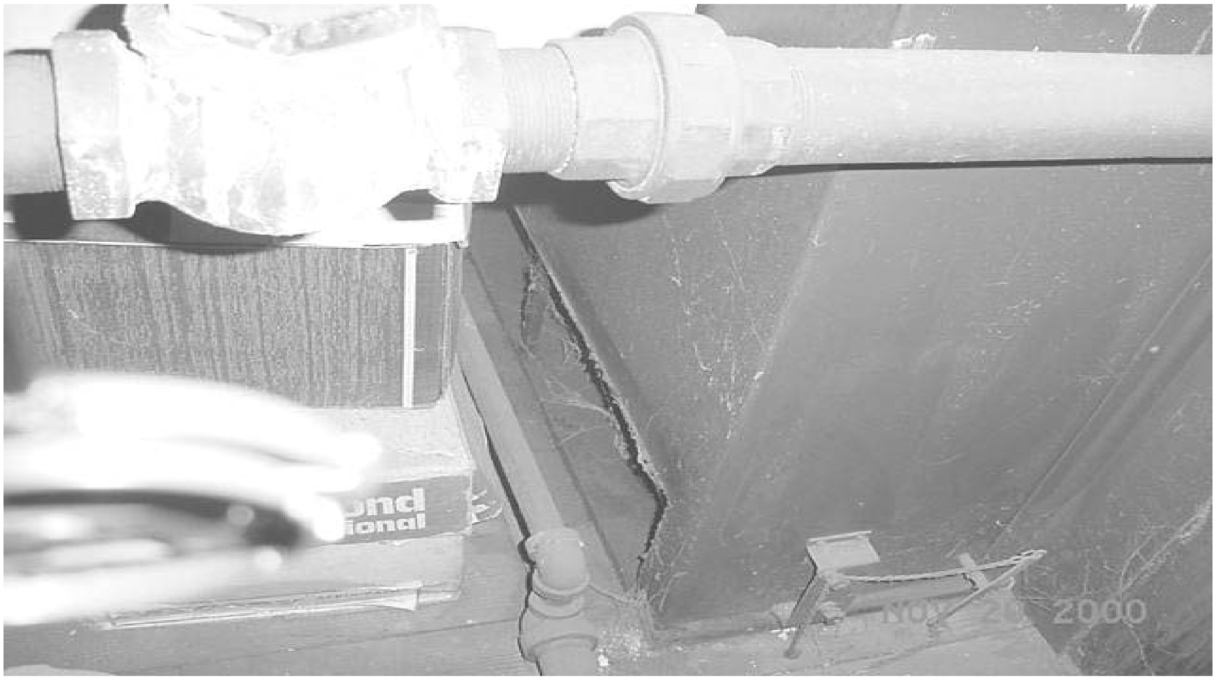
Picture 9

Sealed air intake **Univent**



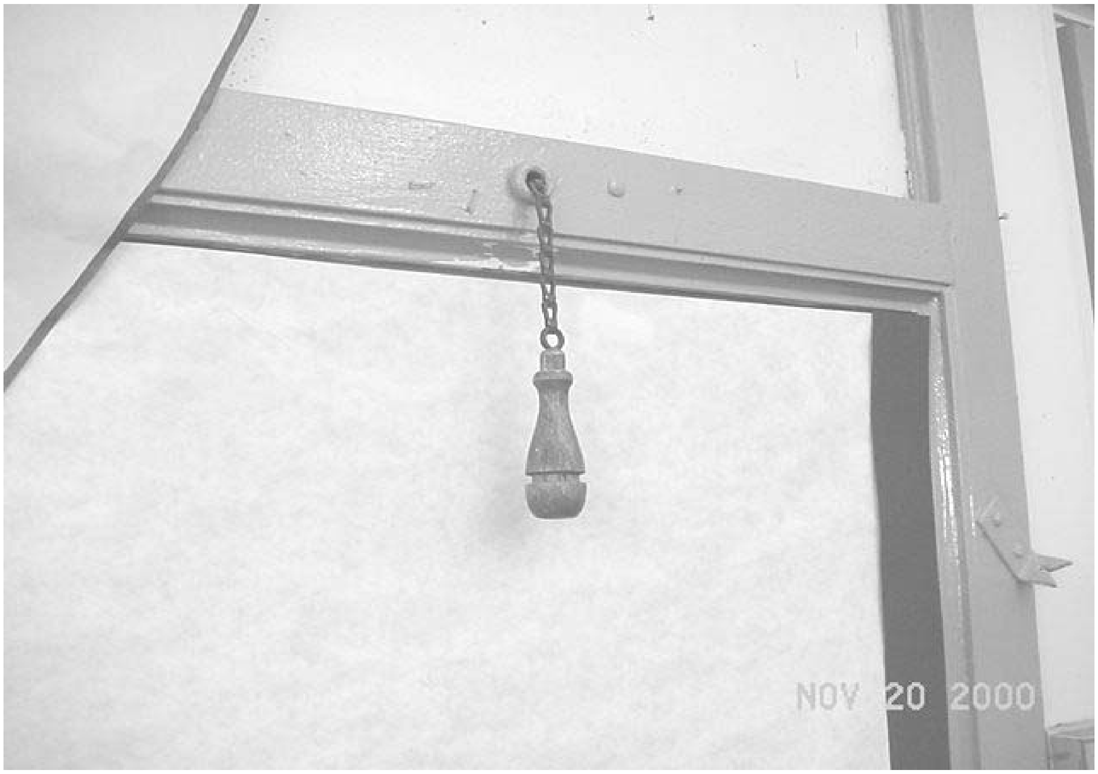
Univent Air Mixing Room Between Classrooms, Note Plywood Sealing Fresh Air Intake and Materials Obstructing Airflow to the Univent

Picture 10



Close-up of Univent Air Intake, Steam Pipes and Materials Stored in “Loft” area between Classrooms

Picture 11

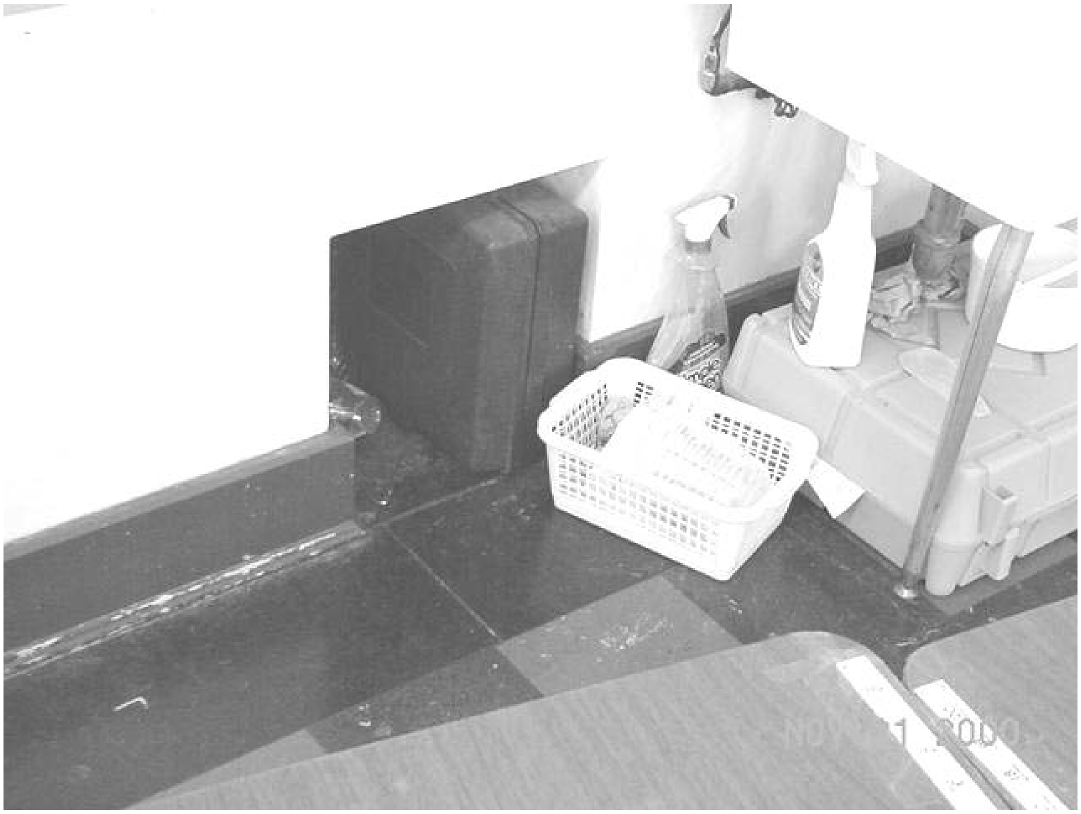


Draw-Chain Pulley System Controlling Exhaust Flue in Classroom

Picture 12

Classroom Univent Covered with Materials (top) and Return Vent Obstructed (front) 1940's Addition

Picture 13

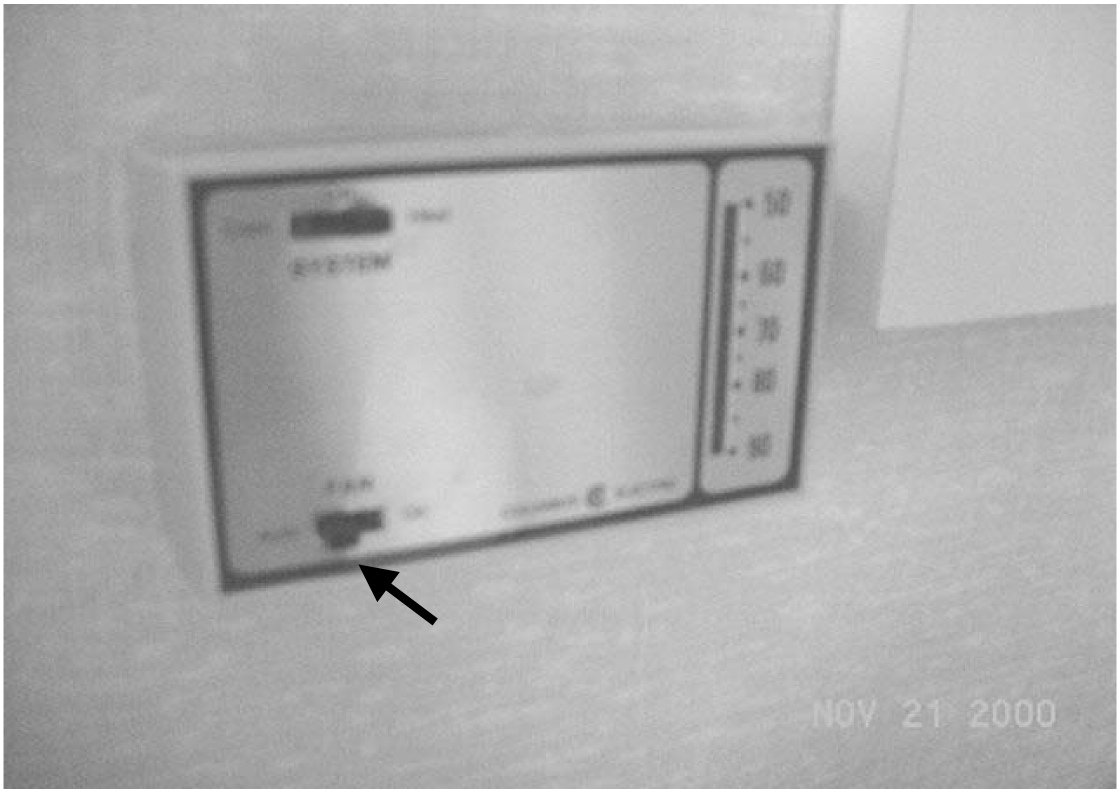


Exhaust Cubby Filled with Stored Materials

Picture 14

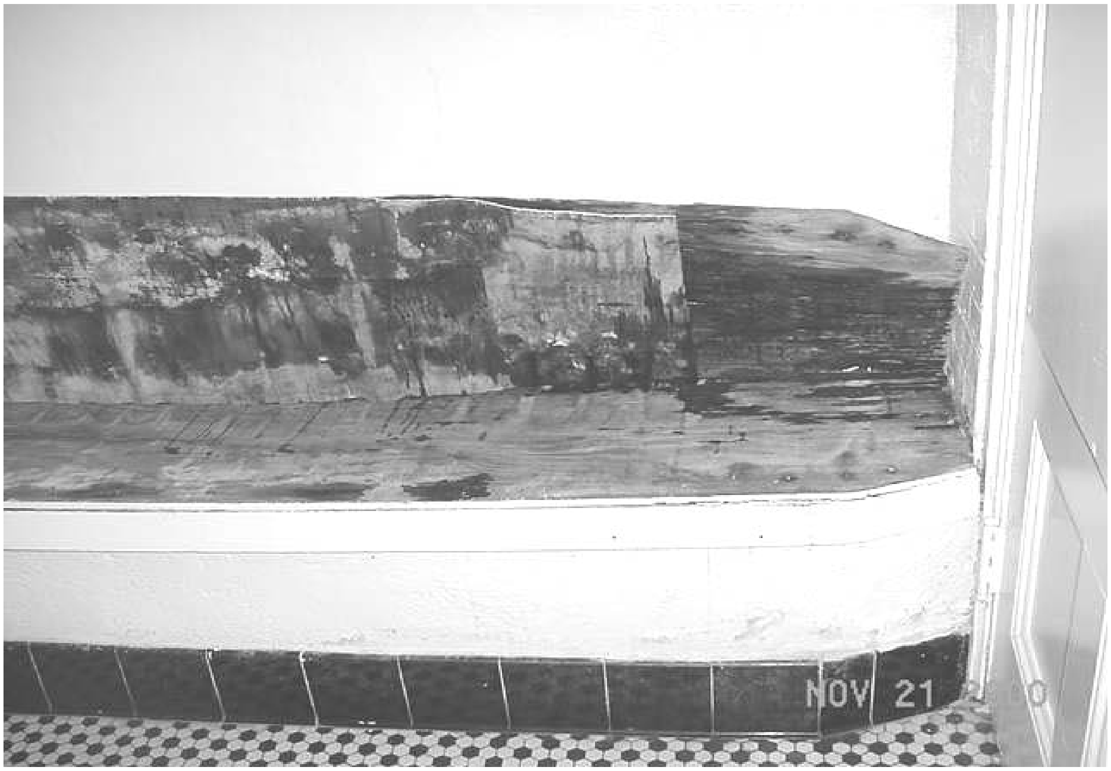
Side-Mounted AHU for Modular Classrooms

Picture 15



Modular Classroom Thermostat Note Fan Control Switch on "Auto"

Picture 16



Water Damaged/Mold Colonized Wood in Girl's Restroom in Area Where Steam Leak Occurred

Picture 17

Drip Pan Installed in Attic-Attached to PVC Drainpipe

Picture 18

Water Damaged Ceiling Tiles in Classroom

Picture 19

Water Damaged Wall Plaster in Resource Room (Former Shower Area)

Picture 20

Condensation on Wooden Windowsill in the Speech Room

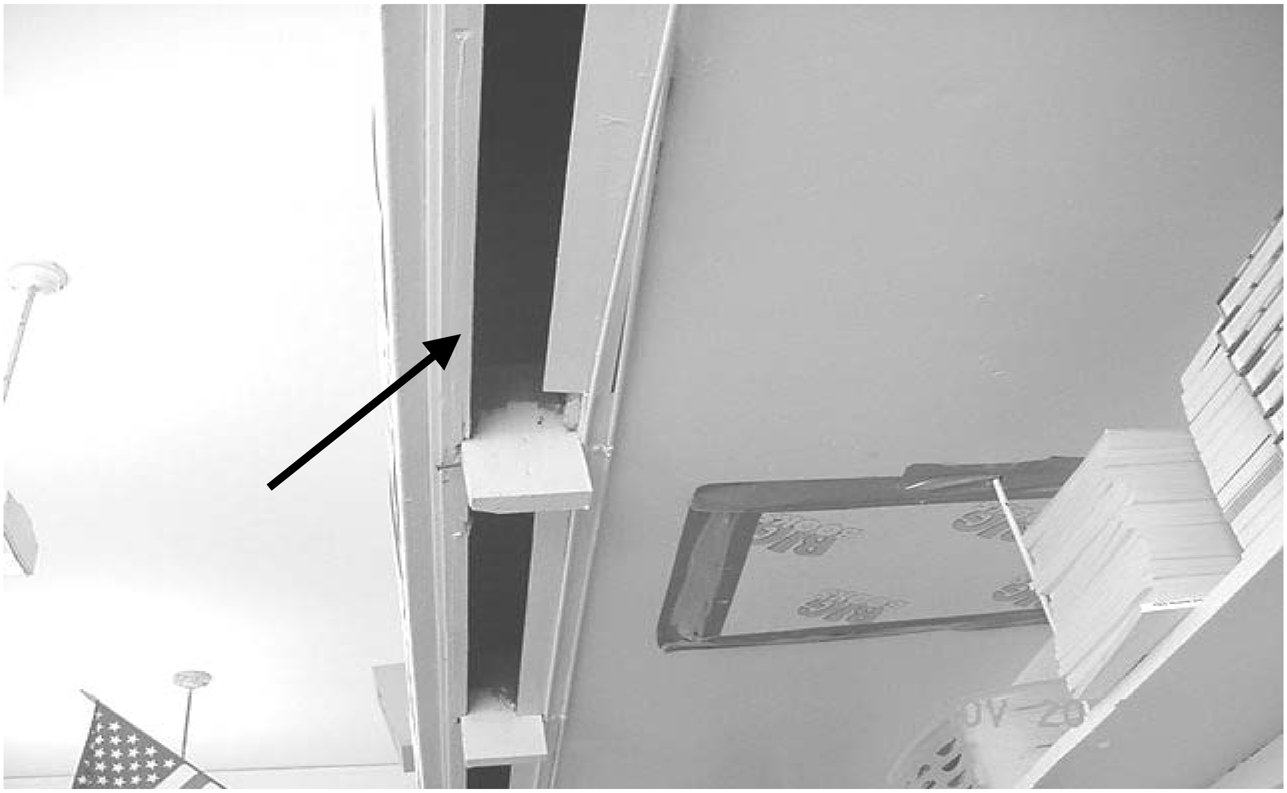
Picture 21

Univent Fresh Air Intake at Ground Level

Picture 22

Roof Drain

Picture 23



Space in Coat Closet Open to the Attic Containing Fiberglass Insulation

Picture 24

Mimeograph Machine and Flammable Duplicating Fluid

Picture 25

Spray Cleaning Products in Classroom

Picture 26

Inactive Wasp’s Nest in Classroom near Univent

Picture 27

Bird's Nest in Classroom

TABLE 1

Indoor Air Test Results – Batchelder Elementary School, North Reading, MA – November 20, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	438	52	34					Weather conditions: cold/cloudy
Room 3-Computer Room	1082	70	37	19	Yes	No	No	Window open, main frame in closet-passive vents, 19 computers, temperature complaints (heat)
Attic								Fiberglass insulation, aluminum/sheet metal ductwork, drain pan-cupola leaks
Room 4-Library	1600	70	35	5	Yes	No	No	5 plants
Room 5	1831	73	36	20	Yes	No	No	3 plants, ceiling open to attic
Room 9	1400	73	34	1	Yes	No	No	Window open, coat closet vent open-slight draw
Room 2	1846	73	36	23	Yes	Yes	Yes	Accumulated materials, exhaust vent blocked
Room 1	1459	74	30	23	Yes	Yes	Yes	Window open, mixing rooms between classrooms-storage of boxes/cardboard items, very hot pipes, air intake sealed, exhaust vent blocked by cabinet

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Batchelder Elementary School, North Reading, MA – November 20, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Councilor's Office	1042	74	31	4	Yes	No	No	Window open, temperature complaints (heat)-small room/large radiator
Room 8	1200	69	38	0	Yes	No	No	
Room 7	1928	69	40	0	Yes	No	No	Occupants gone 1 minute
Speech Room	1365	67	46	0	Yes	No	No	Dry erase board, thick carpet-old/worn, window condensation
Room 10	1615	68	44	23	Yes	Yes	Yes	Air intake sealed, exhaust sealed
Gym	1848	71	39	22	Yes	No	No	Broken window
Resource Room-Old Building	1006	77	30	0	Yes	No	No	Old shower room, temperature complaints (heat), CT, fiberglass ceiling tile, water damaged wall plaster near window-efflorescence, carpets
Girl's Restroom		76	40	0	Yes	No	Yes	Steam leak, water damaged wood-mold growth
Room 11-Reading Room	1037	75	30	0	Yes	Yes	No	Univent off, exhaust sealed

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Batchelder Elementary School, North Reading, MA – November 20, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Tech Office	1140	74	30	0	No	No	No	Dry erase board
Para-Professionals' Office	1139	72	33	1	Yes	No	No	Photocopier (Rizzo), 2 lamination machines, kiln-vented, damaged fiberglass insulation (pipes), mimeograph/duplicating fluid
Teachers' Room	1310	72	37	6	Yes	Yes	No	Univent off, photocopier
Nurse's Office	1015	72	33	2	Yes	No	No	
Room 12	960	73	31	1	Yes	Yes	Yes	Door open, items on univent, exhaust "cubby" filled with stored items-blocked, dry erase board, 21 occupants gone ~1 hr.
Room 17	900			1	Yes	Yes	Yes	Univent noises, exhaust blocked by file cabinet
Room 13	1646	73	40	17	Yes	Yes	No	Univent covered by papers/items-univent off, abandoned toilet
Room 14	1720	74	37	20	Yes	Yes	Yes	Univent off, exhaust off-items in "cubby"
Room 16	1769	74	37	25	Yes	Yes	Yes	Univent blocked

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Batchelder Elementary School, North Reading, MA – November 20, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 15	1714	74	37	21	Yes	Yes	Yes	Door open, univent off-return blocked, exhaust blocked
SE Stairwell-1st/2nd floor								Water damaged wall plaster, efflorescence (corner)
Room 21 – Art Room	902	71	29	0	Yes	Yes	Yes	Univent covered with items-return blocked, spray cleaner on counter, feather duster
Room 22	1191	72	32	24	Yes	Yes	Yes	Door open, exhaust vent blocked, gerbil-clean cage
Room 20	1001	72	30	5	Yes	Yes	Yes	Door open, univent return blocked
Room 23	13	72	35	1	Yes	Yes	Yes	21 occupants gone ~5 min., univent return blocked, exhaust blocked, 4 plants, door open, 1 CT
Room 19	1361	73	33	2	Yes	Yes	Yes	21 occupants gone ~15 min., cleaning product on chalk tray & floor (spray), exhaust vent blocked
Room 18	1480	74	32	22	Yes	Yes	Yes	Bird's nest, 4 plants
Cafeteria	1098	68	32	2	Yes	Yes		3 ceiling mounted univents-off (1 under repair), 4 CT, exhaust could not be identified

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Batchelder Elementary School, North Reading, MA – November 20, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Modular 1 – Music Room	3660	70	43	20	Yes	Yes	Yes	Thermostat on Auto
Modular 2	2746	64	56	14	Yes	Yes	Yes	Thermostat on Auto
Modular 3	3780	69	58	20	Yes	Yes	Yes	Thermostat on Auto
Modular 4	3332	71	53	22	Yes	Yes	Yes	1 CT, Thermostat on Auto
Principal's Office	1422	76	31	3	Yes	No	No	Window mounted a/c
Office	1500	75	31	2	Yes	No	No	Window mounted a/c

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CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%